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(54) **Mobile bearing total joint replacement**

(57) A prosthetic component is provided for a condylar joint. The prosthetic component includes a platform having a bearing surface and a pair of side walls. The side walls include a pair of concave surfaces which face one another and define arcs of the same right circular cylinder. The prosthetic component also includes a plastic bearing having a bearing surface slidably engaged with the bearing surface of the platform. The bearing also includes thrust surfaces defining arcs of two right circular cylinders having radii less than the radius of the side wall surfaces of the platform. The thrust surfaces are spaced from one another to permit only limited sliding movement of the bearing in medial to lateral directions, but greater sliding movement in anterior to posterior directions.

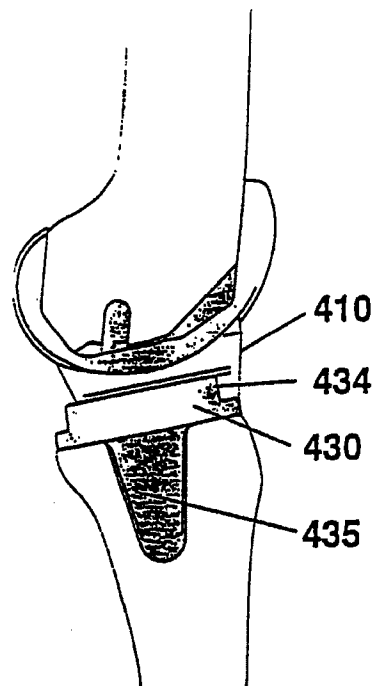


Fig. 1

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention. The invention generally relates to mobile bearing total joint replacements, particularly those of the knee.

2. Description of the Prior Art. Prior art mobile bearing total joint replacement prostheses are described in U.S. patents by Noiles 4,219,893, Goodfellow and O'Connor 4,085,466 and Buechel and Pappas 4,309,778 and 4,340,978. Noiles, in particular describes a mobile bearing knee in which a bearing is retained by side walls of a tibial platform. The inner face of the side walls of the Noiles tibial platform are circular cylinders, as is the complementary side wall of the bearing. Noiles provides a small, uniform clearance that allows some small amount of anterior-posterior (A-P) motion in addition to axial rotation of the bearing relative to the tibial components. This clearance produces medial lateral (M-L) play in the knee roughly equal to the A-P motion, and thus is undesirable. An increase in A-P motion produced by an increase in clearance is undesirable since such an increase produces additional undesirable M-L play. Further the bearing shown by Noiles is retained only by these side walls and the action of the femoral component in concert with the ligaments of the knee. Such restraint may be insufficient to prevent dislocation of the bearing for designs with a larger amount of engagement between the femoral and tibial bearing condyles than that shown by Noiles, or where the ligaments are lax.

The objective of this invention is to increase the amount of A-P motion without increasing the M-L play in the knee and to provide additional means for preventing dislocation of the bearing in those situations where such additional restraint is desirable.

SUMMARY OF THE INVENTION

A prosthetic component is provided for a condylar joint, such as a knee. The prosthetic component includes a metallic platform having an inferiorly disposed bone attachment portion and a superiorly disposed bearing surface. Spaced apart medial and lateral side walls project from the bearing surface. The medial and lateral side walls each include an anterior end, a posterior end and a concave surface extending therebetween. The concave surfaces face one another, and preferably define arcs of a single right circular cylinder having a radius R_1 .

The prosthetic component of the subject invention further includes a plastic bearing having an inferior bearing surface slidably engaged on the superior bearing surface of the platform. The bearing includes medial and lateral thrust surfaces extending from the inferior bearing surface and defining arcs of two separate right circular cylinders having radii R_2 , which are less than the radius R_1 on the medial and lateral side walls of the plat-

form. The medial and lateral thrust surfaces are spaced from one another distances that permit a minor medial to lateral (M-L) clearance between the thrust surfaces and the respective side walls of the platform. The radii R_2 and R_1 are selected relative to the M-L clearance to permit greater sliding movement of the bearing in an anterior-to-posterior direction than in a medial-to-lateral direction.

The inferior surface of the bearing may further be characterized by a cavity extending therein. The superior bearing surface of the platform may include a button slidably engaged in the cavity. The relative dimensions of the cavity and the button may be selected to permit the full range of M-L and A-P movement that are controlled by the side walls of the platform. The button and the cavity may include interlocking structure for maintaining the inferior bearing surface of the bearing and the superior bearing surface of the platform in generally abutting sliding engagement with one another.

The provision of thrust surfaces defining arc segments of two right circular cylinders enables the prosthetic component to provide a desirably large range of anterior to posterior movement and a desirably small range of medial to lateral movement between the bearing and the platform.

The invention also is directed to a system of prosthetic components employing a single platform and a plurality of bearings one of which may be selected intraoperatively or during a surgical revision to permit an appropriate range of movement between the bearing and the platform for the particular patient. For example, an alternate bearing to the one described above may permit only minor sliding movement in all directions and rotational movement. In other embodiments the bearing may be constructed to lockingly engage the platform to prevent substantially all movement between the bearing and the platform.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a lateral view of a mobile bearing knee replacement in accordance with the subject invention.

FIG. 2 is an anterior view of the knee replacement shown in FIG. 1.

FIG. 3 is a lateral view similar to FIG. 1, but showing the knee replacement at about 90° of flexion.

FIG. 4 is a saggital sectional view of a plastic bearing of the tibial component of the knee replacement.

FIG. 5 is a saggital sectional view of the metallic tibial platform of the tibial component of the knee replacement.

FIG. 6 is a coronal sectional view of the plastic bearing.

FIG. 7 is a coronal sectional view of the tibial platform.

FIG. 8 is a superior view of the plastic bearing.

FIG. 9 is a superior view of the tibial platform.

FIG. 10 is an inferior view of the plastic bearing.

FIG. 11 is a superior view of the assembled tibial component.

FIG. 12 is a saggital sectional view of the assembled tibial component.

FIG. 13 is a coronal sectional view of the assembled tibial component.

FIG. 14 is a superior view of the tibial platform with a transparent view of the inferior bearing region and the cavity thereof.

FIG. 15 is a superior view similar to FIG. 14 but with the bearing moved in a medial-lateral direction relative to the tibial platform.

FIG. 16 is a superior view similar to FIG. 14 but showing the bearing at the most posterior position relative to the tibial platform.

FIG. 17 is a superior view similar to FIG. 16, but showing the bearing at the maximum anterior position relative to the tibial platform.

FIG. 18 is a saggital cross-sectional view of an alternate bearing.

FIG. 19 is an inferior view of the bearing shown in FIG. 18.

FIG. 20 is a superior view of the tibial platform and a transparent view of the inferior bearing region at an intermediate step during their assembly.

FIG. 21 is a superior view similar to FIG. 20, but showing the bearing and tibial platform in their fully assembled condition.

FIG. 22 is a saggital cross-sectional view of a third embodiment of a bearing that can be fixedly secured to the tibial component.

FIG. 23 is an inferior view of the bearing shown in FIG. 22.

FIG. 24 shows the bearing of FIG. 22 and 23 fixedly mounted to the tibial component.

FIG. 25 is a saggital cross-sectional view of another alternate bearing.

FIG. 26 is a saggital cross-sectional view of the tibial platform for use with the bearing of FIG. 25.

FIG. 27 is a saggital cross-sectional view of the bearing on FIG. 25 assembled to the tibial platform of FIG. 26.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. 1 and 2 show lateral and anterior views respectively of the knee replacement 100. The knee replacement 100 consists of a femoral component 200 which is fixtured to the distal femur 300. Metallic femoral component 200 is essentially the same as that described in U.S. patents 4,309,778 and 4,340,978. A tibial component 400 consists a plastic bearing 410 and metallic tibial platform 430 which is fixtured to the proximal tibia 500.

FIGS. 1 and 3 show a lateral view of the knee replacement in full extension and about 90° of flexion respectively. At full extension the bearing will usually be in an anterior position as shown in FIG. 1. As the knee

is flexed, the action of the ligaments in concert with the shape of the femoral articulating surface 201 and the tibial articulating surface 411 generate posterior displacement of the bearing 410 relative to the tibial platform 430 so that the bearing 410 occupies a posterior position as shown in FIG. 3.

Where a mobile bearing, as shown in FIGS. 1 and 3 which moves relative to the tibial platform 430, is employed, the shape of the femoral articulating surface 201 preferably is complimentary, at least for some of the range of flexion of the joint, to the tibial articulating surface 411. A mobile bearing is needed, where these articulating surfaces are congruent, in order to provide motion of the knee approximating normal. A mobile bearing is also useful where there is moderate incongruity of these surfaces. Adequate motion can be obtained, however, with designs where the bearing does not move relative to the tibial platform 430 (fixed bearing). Such fixed bearing designs generally have substantially higher contact stress and wear than mobile bearing designs.

FIGS. 4 and 5 show saggital sectional views, FIGS 6 and 7 coronal sectional views and FIGS. 8 and 9 superior views of the tibial platform 430 and an A-P Glide embodiment of a bearing 410 respectively. FIG. 10 shows an inferior view of the bearing.

The tibial platform 430 consists of a load bearing plate 431, side walls 432 with faces 433 and side wall ends 434 and a fixturing stem 435. The two faces 433 together form segments of the same right circular cylinder of radius R_t . Thus any bearing fitting entirely within this cylinder is free to rotate on the load bearing plate 431. This plate may also have a button 436 with two flats 437, button side walls 438 with a recess groove 439. The side walls 433 preferably are disposed at the extreme medial and lateral aspects of the tibial platform in order to provide the largest possible wall radius, thereby minimizing contact stress and maximizing A-P motion.

The bearing 410 consists of an inferior bearing surface 412, a tibial articulating surface 411, two thrust surfaces 413 which are segments of two right circular cylinders of radius R_b , an anterior recess 414 to clear the patella tendon and a posterior recess 415 to clear to posterior cruciate ligament. The bearing 410 may also have a cavity 416 with a central hole 417, oval side walls 418 and cylindrical ends 419 with ridges 420. FIGS. 11, 12 and 13 show superior and saggital and coronal sections of the assembled bearing and tibial platform respectively.

FIGS. 14-17 shows superior views of the tibial platform 430 and a transparent view of the inferior bearing region 421 with cavity 416. FIG. 14 shows cavity 416 centered on button 436. In this position the button 436 will fit into the central hole 417 and allow the inferior bearing surface 412 to seat centrally on the load bearing plate 431 of tibial component 430. In this position there will be a clearance with a minimum value of "A"

between the thrust surfaces 413 of the bearing and the faces 433 of the side walls 432 of the tibial platform 430.

Under the action of M-L shearing forces in the knee the bearing 410 will move medially or laterally relative to the tibial platform 430 until a thrust surface 413 of the bearing 410 with a radius equal to R_b contacts a corresponding face 433 of the tibial platform 430 with a radius R_t , as shown in FIG. 15. The oval side walls 418 provide clearance between them and the button side walls 438 in this position so that such medial or lateral motion is permitted.

The values of these radii R_b and R_t are critical to effective functioning of the prosthetic component 100. The embodiment shown uses values of $R_b = 0.850$ " and $R_t = 1.252$ " or in non-dimensional form a Radius Ratio $R_b/R_t = 0.68$. Using a clearance $A = 0.025$ " these radii produce a total A-P travel of $C = .29$ ". These values, excluding the non-dimensional Radius Ratio, are associated with a particular, and most common size tibial component. The values of radii, clearance, and resulting A-P motion can be proportionally scaled to the size of the tibial platform for other sizes. For a particular size, increasing "A" will increase "C" at the expense of increased undesirable M-L play. Decreasing the Radius Ratio will also increase A-P motion but at the expense of an undesirable increase in the contact stress. The values above represent a preferred embodiment although values of "A" from 0.020" to 0.060" and Radius Ratio from 0.20 to 0.90 are useful.

FIGS. 16 and 17 show the most posterior and anterior positions of the bearing 410 relative to the tibial platform 430 respectively. In these positions contact between the thrust surfaces 413 and side wall 433 can restrict further A-P motion. Alternately contact between the button side walls 438 and the cylindrical ends 419 of the cavity 416 can stop the motion. In these positions the ridges 420 of cavity 416 engage the recess groove 439 in the button 436. This engagement prevents dislocation of the bearing 410 from the tibial platform in these positions by resisting lifting forces resulting from tilting of the bearing 410 on the load bearing plate 431 of the tibial platform 430. It is these positions that produce the tilting forces associated with motion limitation which may produce such dislocation. At the extremes of A-P motion no side clearance is needed between the button side walls 438 and the cylindrical ends 419 since in these positions there is no M-L side play between the thrust surfaces 413 and the side walls 433.

The use of a separate means for resisting medial-lateral thrust loads and retention against bearing lifting has the advantage that the thrust surfaces can be simple right circular cylinders which can be accurately made at reasonable cost thereby providing greater conformity of the thrust surfaces reducing contact stress and wear. The lift retention surfaces need not be accurate since they only act at the extremes of motion and are not subject to significant sliding or load.

The bearing 410 is free to rotate relative to the tibial platform 430 on the load bearing plate 431 about an

axis normal to that plate for all positions of the bearing shown, and any other position of the bearing.

The preferred embodiment described above is intended for cases where there is a viable posterior cruciate ligament but no viable anterior cruciate ligament. Such cases account for about 65% of knee replacement surgeries. The device, because it limits A-P motion, and thus provides some A-P stability, is also useful for most cases where neither the posterior nor anterior cruciate ligament are viable. Such cases account for about 30% of knee replacement surgery. Where the posterior cruciate ligament is absent or not viable, some surgeons may prefer to use a device which does not allow significant A-P motion, and thus provides enhanced A-P stability.

An alternate, Rotational Bearing, embodiment which allows only axial rotation of a rotational bearing is shown in FIGS. 18 and 19 and which are a coronal cross-section and inferior view respectively of a rotational bearing 440. This rotational bearing 440 contains a rotational inferior bearing surface 442 and rotational thrust surfaces 443 which are segments of the same right circular cylinder of a radius about .005" smaller than R_t . The rotational bearing 440 may also contain a rotational cavity 445 with a rectangular hole 446 and a rotational circular hole 446 with rotational ridges 448. FIGS. 20 and 21 show the method of installation of rotational bearing 440 onto the tibial platform 420. The rotational bearing 440 is positioned as shown in FIG. 20 so the long sides 449 of the rectangular hole 446 are aligned with the flats 437 on button 438. The button will now enter the rotational circular hole 446 and allow the rotational inferior bearing surface 442 to engage the tibial load bearing plate 431. The rotational bearing 440 is then rotated 90° to the position shown in FIG. 21. This rotation causes the rotational ridges 448 to engage the recess groove 439 in button 436. This retains the rotational bearing 440 against dislocation from the tibial platform 430 in normal use since 90° of bearing rotation is not encountered in the human knee. In this embodiment R_b is about equal to R_t and thus significant A-P motion is inhibited. Only axial rotation occurs. Shearing loads are easily carried by the congruent contact associated with rotational thrust surfaces 443 and faces 433.

Although mobile bearings are preferred over fixed bearings in knee and other joints resulting in lower articulating contact stresses and wear, due to the fear of dislocation and general suspicion of moving parts by orthopaedic surgeons, mobile bearings are limited to only about 5% of the market in the U.S., and less than 10% in Europe. Thus a third, Fixed Bearing, embodiment is useful where the tibial platform 430 is used with a non-mobile, or fixed, bearing. FIGS. 22 and 23 show a sagittal and inferior view of a fixed bearing 450. The assembled bearing and platform are shown in FIG. 24. The fixed bearing 450 consists of a fixed tibial articulating surface 451, not conforming to the femoral articulating art surface 201 a fixed inferior bearing surface 452, fixed thrust surfaces 453 of radius R_t with end recesses

454 and other features similar to the other bearing embodiments. The fixed bearing 450 may also include a cavity 456 with an internal ridge 460.

The fixed bearing 450 is assembled to the tibial platform by aligning the end recesses 454 of the bearing with side wall ends 434 of the tibial platform 430, and engaging, when present, the button 436 of the platform with the cavity 456 in the fixed inferior bearing surface 452. The bearing is then pressed into the platform spreading the internal ridge 460 in the plastic bearing unit it spreads over the button side walls 438 and the ridge engages the recess groove 439 in the button retaining the bearing in the platform.

Both mobile and fixed bearing types can all be used as elements of a knee system consisting of different types of femoral components with different fixation options but with similar articulating surfaces and a series of tibial components. A system employing both bearing types provides greater options for an orthopaedic surgeon or salesman than the typical system which is limited to only fixed or mobile bearing type.

A feature of the tibial platform 430 is that it can accept all three embodiments of the bearing. Normally each bearing type has a different tibial platform. This universality has two benefits. First such a universal platform in a system of tibial implants minimizes inventory requirements reducing the cost of the use of the system while providing maximum options for surgeon preference of bearing type. Secondly in the event of difficulty with one bearing type, a different bearing type can be substituted without removal and exchange of the tibial platform. This might occur, for example, in case of a posterior cruciate rupture producing unacceptable A-P instability. The surgeon could then replace the A-P Glide bearing with a Rotational bearing. Another example is a case of rare rotational instability associated with a mobile bearing. In such a situation the mobile bearing can be replaced by a fixed bearing again without removal and replacement of the tibial platform.

An alternate embodiment of the button retention means useful primarily for the Rotating and Fixed bearings is shown in FIGS. 25-27. As shown in FIG. 25 an alternate tibial platform 460 has a load bearing plate 461 and a retaining button 466 with retaining side walls 468 and a recess groove 469 with a retaining face 467. The alternate bearing 470, shown in FIG. 26, has an inferior bearing surface 472 and a retaining cavity 476 with a segmented flexible retaining lip 477 with a retaining end 478.

To assemble the alternate bearing and tibial platform the retaining cavity is placed onto the retaining button. As the alternate bearing moves downward toward the alternate tibial platform the retaining end 478 of the flexible segmented lip 477 engages the retaining side walls 468 and are flexed outward allowing the motion to continue. When the inferior bearing surface 472 is seated on the tibial load bearing surface 461 the retaining end will be clear of the retaining side wall and will be free to move inwardly. After this inward motion the

retaining end 478 engages the retaining face 467. The lip and face are configured such that upward motion of the bearing relative to the tibial platform is prevented in that such motion would tend to produce inward motion of the lip, which motion is prevented by the contact between the lip end and retaining face.

The preferred material for the metallic components is titanium alloy coated with a titanium nitride ceramic. Cobalt chromium alloy is however used much more extensively, and is a suitable material. The preferred plastic is wear resistant, and surgical, grade polyethylene. Other materials may also be useful.

Although the embodiments shown are for knee replacement such designs are also useful for other condylar joints such as the finger, thumb, toes, elbow and ankle.

Claims

1. A prosthetic joint replacement for a condylar joint comprising:

a first prosthetic component (200) having a bone attachment portion for attachment to a first bone (300) of the condylar joint and having an articular surface (201);

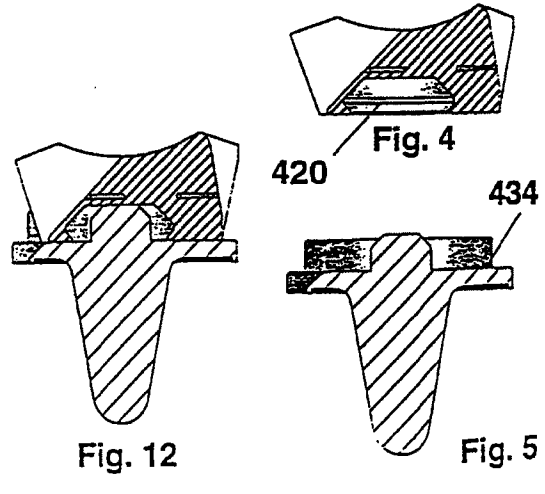
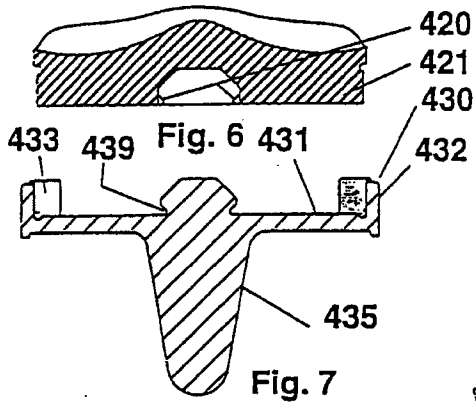
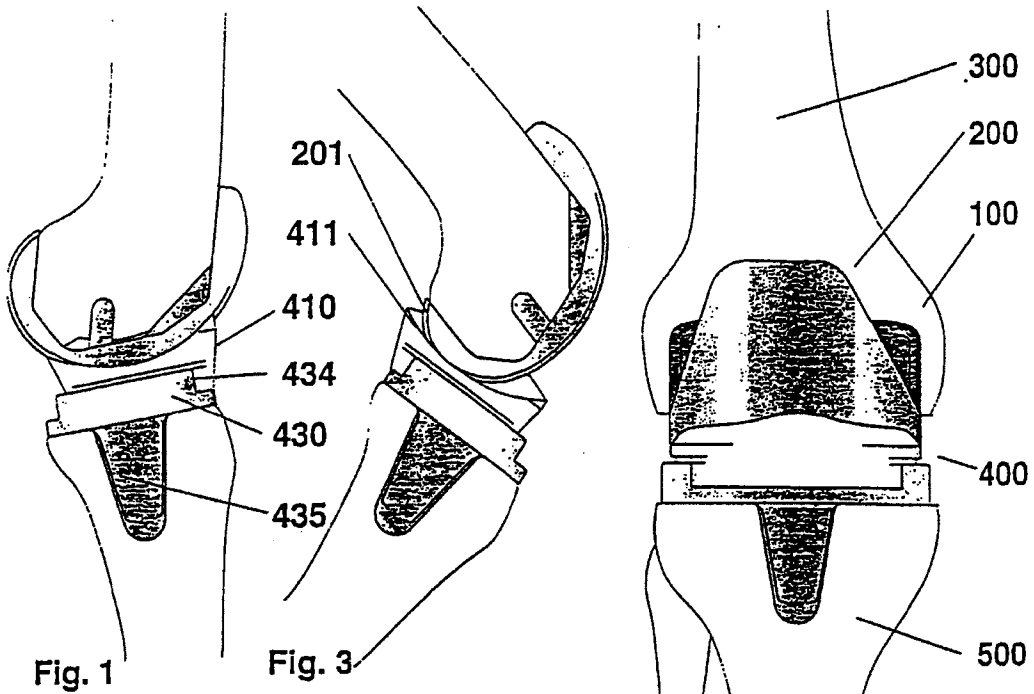
a second prosthetic component (430) defining a platform having a bone attachment portion (435) for attachment to a second bone (500) of the condylar joint and having a bearing surface (431);

a bearing (410) disposed between said first and second prosthetic components (200, 430), said bearing (410) having a first bearing surface (411) in articular bearing engagement with the articular surface (201) of the first prosthetic component (200) and a second bearing surface (412) engaged with the bearing surface (431) of the second prosthetic component (430);

said prosthetic joint being characterized in that: said second prosthetic component (430) comprising medial and lateral side walls (432, 433) projecting from said bearing surface (431), each said side wall (432, 433) having an interior end, a posterior end and a concave surface therebetween, said concave surfaces of said medial and lateral side walls (432, 433) facing one another, said bearing (410) having medial and lateral thrust surfaces (413) facing the medial and lateral side walls (432, 433) of the second prosthetic component (430), the thrust surfaces (413) and the medial and lateral side walls (432, 433) cooperating for limiting sliding movement between said bearing (410) and said second prosthetic component (430).

2. A prosthetic joint replacement according to claim 1, wherein the thrust surfaces (413) of said bearing

- (410) are dimensioned and configured relative to the side walls (432, 433) to permit substantially greater anterior and posterior sliding movement of said bearing (410) on said second prosthetic component (430) than medial and lateral sliding movement of said bearing (410) on said second prosthetic component (430).
3. A prosthetic joint replacement according to claim 1 or 2, wherein the thrust surfaces (413) of the bearing (410) are spaced in a medial-to-lateral direction to define selected M-L clearances between said bearing (410) and the respective medial and lateral side walls (432, 433) of the second prosthetic component (430), said thrust surfaces (413) of said bearing (410) and said side walls (432, 433) of said second prosthetic component (430) being dimensioned and configured to permit sliding movement in anterior and posterior directions which significantly exceed the M-L clearances.
 4. A prosthetic joint replacement according to any of claims 1-3, wherein the concave surfaces of said side walls (432, 433) of said second prosthetic component (430) define a radius R_1 , and wherein the thrust surfaces (413) of the bearing (410) define radii R_b , the radii R_1 and R_b being selected to define a radius ratio R_b/R_1 in the range of 0.2-0.9 and preferably 0.68.
 5. A prosthetic joint replacement according to any of claims 1-4, wherein the bearing (410) includes a cavity (416) extending into said bearing surface (412) at a location generally centrally between said thrust surfaces (413), said second prosthetic component (430) including a button (436) projecting from said bearing surface (431) at a location concentric with said concave surfaces, said button (436) being slidably and rotatably engaged within said cavity (416).
 6. A prosthetic joint replacement according to claim 5, wherein said cavity (416) and said button (436) are dimensioned to provide medial and lateral clearances no less than the medial and lateral clearances between the thrust surfaces (413) of the bearing (410) and the side walls (432, 433) of the second prosthetic component (430).
 7. A prosthetic joint replacement of claims 5 or 6, wherein the cavity (416) is of generally oval shape with a long axis aligned in an anterior-posterior direction.
 8. A prosthetic joint replacement according to any of claims 5-7, wherein the cavity and the button are lockingly engaged with one another for maintaining second bearing surface (412) of the plastic bearing (410) and the second prosthetic component (430) in sliding engagement with one another.
 9. A prosthetic joint replacement according to any of claims 1-7, further comprising dislocation prevention means for preventing dislocation of the bearing surface (431) of the second prosthetic component (430) from the second bearing surface (412) of said plastic bearing (410).
 10. A prosthetic joint replacement according to any of claims 1-9, wherein the thrust surfaces (413) of the bearing (410) define arc segments of two right circular cylinders having radii smaller than the radius of the concave surfaces of the second prosthetic component (430).



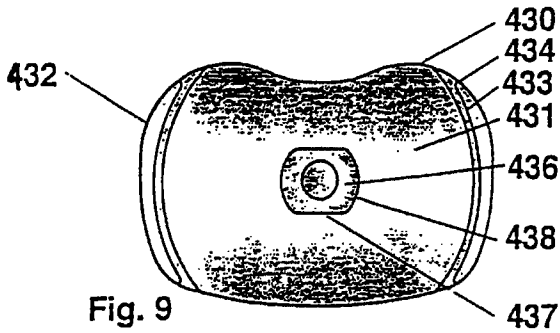


Fig. 9

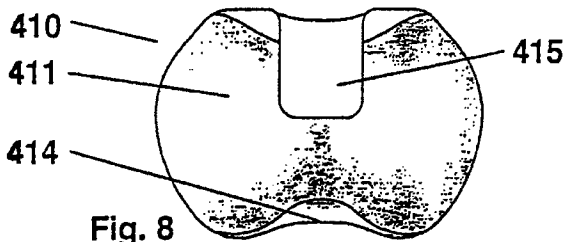
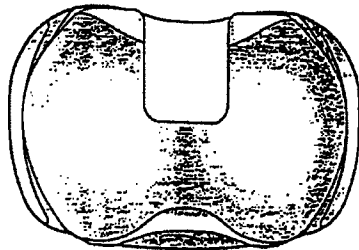


Fig. 8

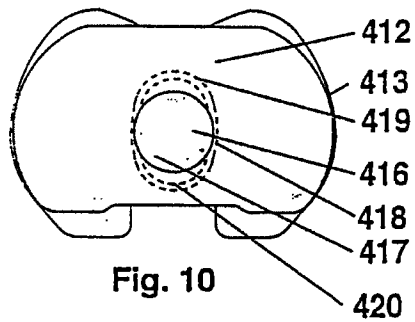


Fig. 10

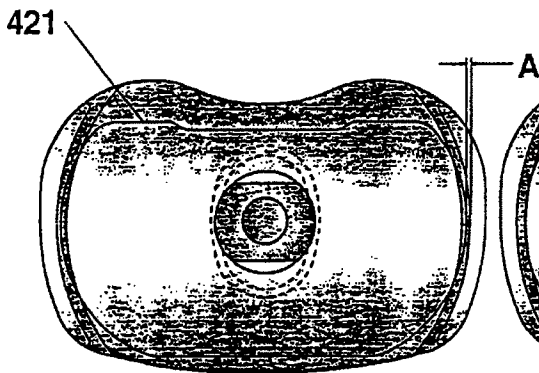


Fig. 14

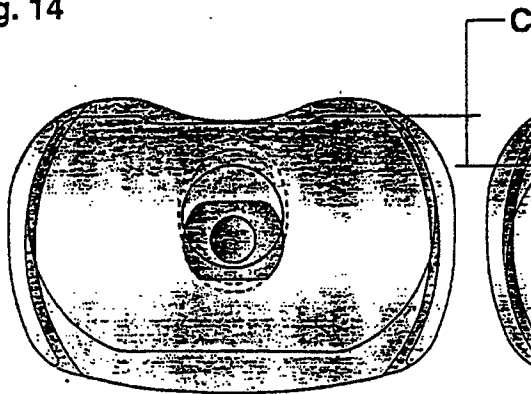
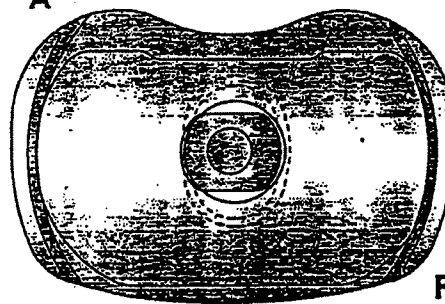
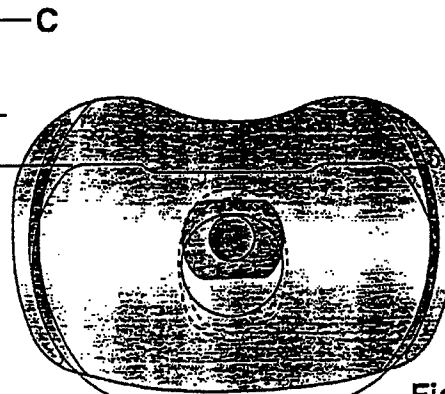


Fig. 16



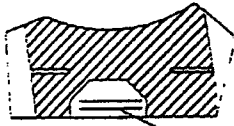


Fig. 18

448

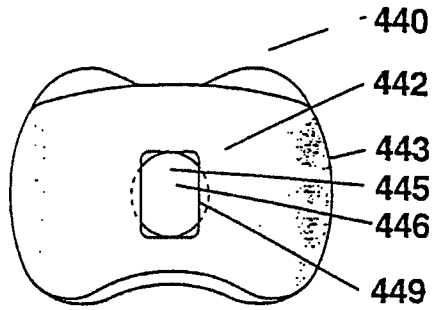


Fig. 19

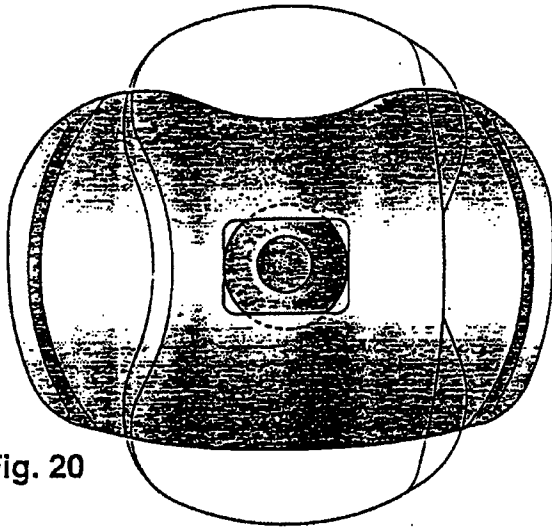


Fig. 20

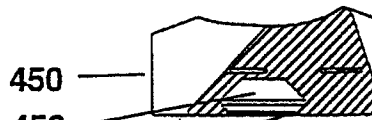


Fig. 22

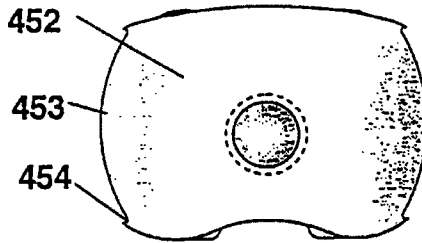


Fig. 23

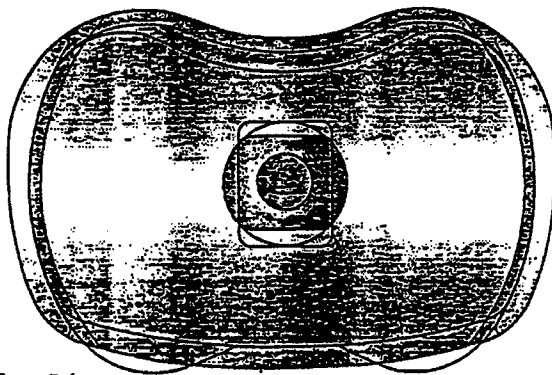


Fig. 21

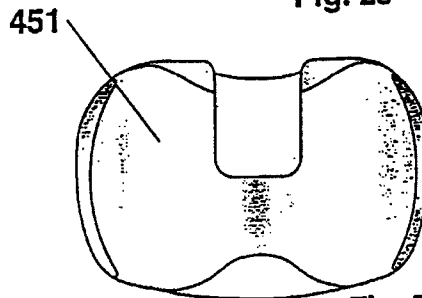


Fig. 24

